Pressure Rise at the RHIC

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I. Intensity limiting vacuum incidents

- **55-bunch gold beam with 9×10^{8} ions/bunch, valve close at IR.**
- **110-bunch with 5×10^{8} ions/bunch, valve close at IR.**
- **110-bunch with 8×10^{8} ions/bunch, valve close at warm bore when about 30 bunches injected.**

II. Pressure rise patterns

- **All pressure rise happened in warm sections.**
- **Pressure rise from $<10^{-9}$ Torr to $>10^{-5}$ Torr, higher than 10^{-4} Torr observed.**
- **Pressure rise depends on locations, the rise can be different for same type of chambers. The worst incidents take place in about 1/3 of the warm sections (~ 300 meters total).**

- **Pressure rise was much more serious for the gold run, compared with the proton.**
- **RHIC is the second machine ever the intensity limited by vacuum. ISR vacuum problem was caused by ion desorption. ISR intensity was high, 10^{14} and later 10^{15} protons per ring. The ion desorption cannot explain RHIC pressure rise.**

III. Beam loss effect

- **Beam loss had caused quite a few incidents of valve close, but not for intensity limiting cases.**
- **Each gold ion lost at glancing angle may produce 10^{6} molecules, positive ions can be 5 to 10%.**
- **Gold beam loss creates more ions than the proton beam loss.**
- **Real glancing incident can only happen at long straight sections. It is still a largely unknown factor. However, think of that a high energy gold ion dumps all the energy on the surface of 50 meter long pipe, ...**

IV. Electron cloud

- **Can electron multipacting happen at RHIC?**
  1. **For bunch spacing of 107 ns (110-bunch), most secondary electrons travel 10 cm during the bunch gap and cannot survive. Other machines with electron multipacting, bunch spacing is ~ 20 ns.**
  2. **Beam loss generated ions can help electrons to survive the bunch gap. With this ion-electron plasma, RHIC local electron multipacting becomes possible.**
- **Why RHIC pressure rise (gold) is so violent?**
  1. **Electron multipacting happened at SPS, PEPII, KEKB, and other machines. Associated pressure rises are modest, and take place all over the ring.**
  2. **Calculation shows that with the normal electron saturation density and pumping speed, pressure at RHIC can reach 10^{-7} Torr, similar to other machines. This kind of pressure rise will not lead to valve close.**
  3. **With ion-electron cloud, local electron density can be larger than the space charge limited, and therefore contribute to higher pressure rise.**

- **Why the RHIC pressure rise depends on the location?**
  1. **If the electron multipacting depends on the presence of ions, then the pressure rise distribution is related to the local beam loss and chamber geometry.**
  2. **IP12 and IP4 have same kind of chamber, but IP4 is much less troublesome. Is this because of many chamber interruptions in IP4?**
- **Is electron desorption the dominant factor in pressure rise?**
  1. **Beam loss. Beam loss caused pressure rises are usually faster than the ones observed in intensity limiting cases.**
  2. **Ion desorption. Before reaching the wall, ions will be kicked by many passing bunches. Ion desorption rate could be >1, however, overall gas desorption efficiency not high.**
  3. **Electron desorption. Electrons are much more active. Secondary electrons (SE) hit the wall and replaced by next generation of SE at every bunch passing. Electron desorption rate is ~0.1, but overall desorption efficiency is high.**

- **RHIC seems related with 3 CERN machines that have vacuum pressure problem.**

	LEAR	ISR	SPS	RHIC
Species	Pb^{54+}	p	p	Au^{79+}
E_k	4.2MeV/u	26 GeV	26 GeV	8.9 GeV/u
Cause	Beam Loss	Ion-desorption	Electron cloud	Loss-ion-electron?
Fix	'Sawtooth' Surface?	Pumping	EC control?	solenoid?

Vacuum pressure rise comparison

V. Diagnostics

- **Coherent tune shift in bunches. Upward tune shift observed.**
- **Electron detector.**

1. **To detect the electron multipacting, and ions.**
2. **Timing of multipacting can be compared with the pressure rise.**
3. **Detector is designed to help determining the electron density.**
4. **The electron density, electron desorption rate, local pumping speed, and the pressure rise can be compared to determine the real cause of pressure rise.**

VI. Solenoid

- **Solenoid installation is under discussion. Primary issues: solenoid strength of 50 Gauss, similar to the ones used at KEKB and PEPII. Coverage in the ring is to be determined.**
- **Warm sections have been identified according to the pressure rise history and plan of bake-out. Sections that without bake-out plan and with pressure rise history have priority for solenoids.**
- **Further justification of the use of solenoid.**